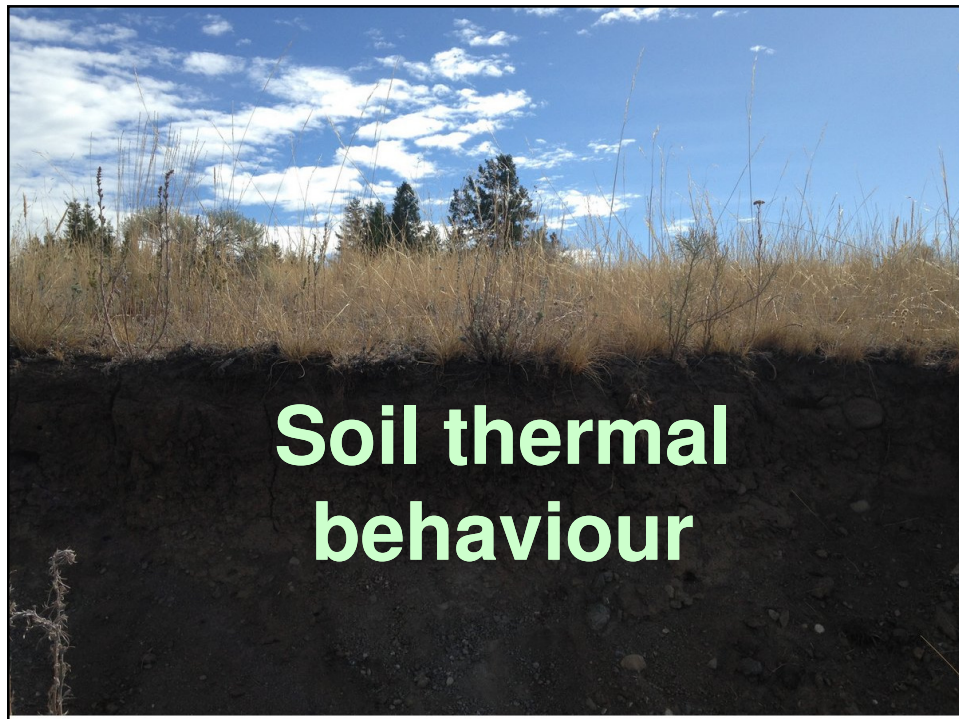


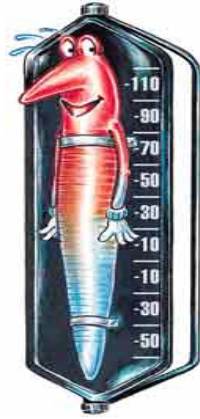


Lecture outline

- A. Soil thermal behavior
- B. Soil thermal properties

3

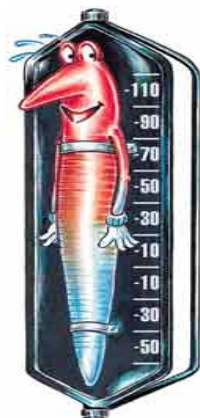




What is
heat?

- **Heat** represents transfer of energy from one body to another, due to the difference in temperature

5



What is
temperature?

- **Temperature** is a measure of kinetic energy of individual molecules

6

Heat transfer is due to:

- **Conduction**
(through molecular collisions)
- **Convection**
(by mass movement of molecules)
- **Radiation**
(by electromagnetic waves)

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Fourier's Law of Heat Conduction

$$G = -\lambda \frac{dT}{dx}$$

G = heat flux density [J/m²s]

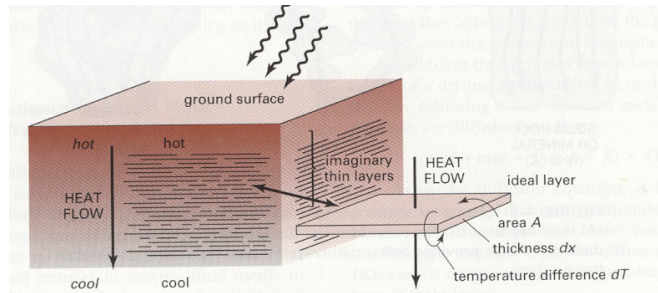
λ = thermal conductivity [J/ms°C]

dT/dx = temperature gradient [°C/m]

8

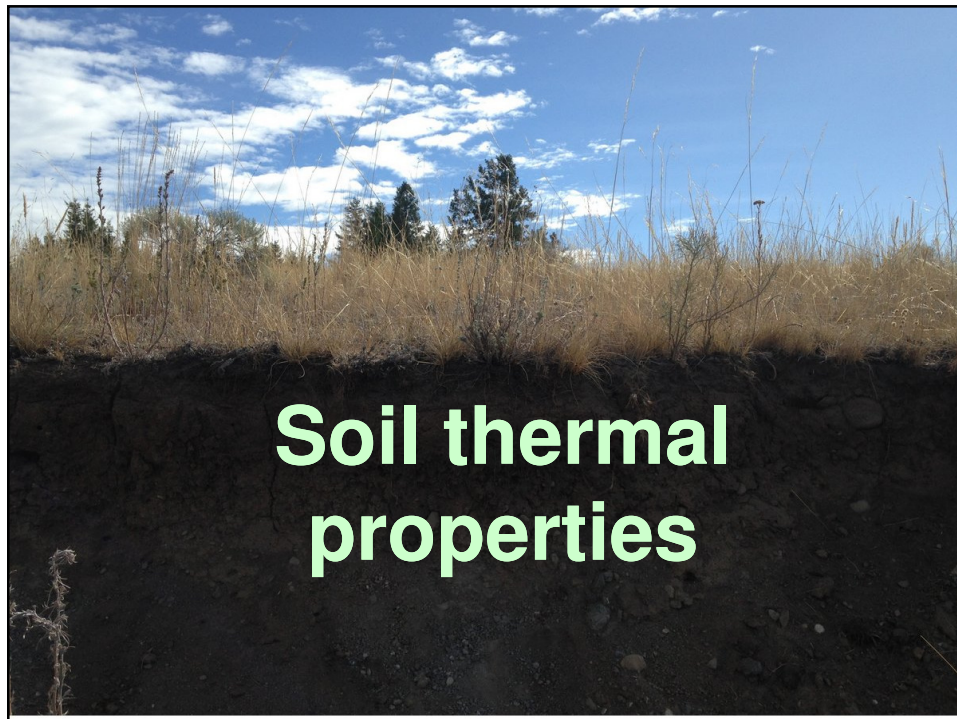
$$G = -\lambda \frac{dT}{dx}$$

G = heat flux density [$\text{J}/\text{m}^2\text{s}$]
 λ = thermal conductivity [$\text{J}/\text{ms}^\circ\text{C}$]
 dT/dx = temperature gradient [$^\circ\text{C}/\text{m}$]



Heat flux density (G) is the rate of heat flow crossing the plane in unit time [$\text{J}/\text{m}^2\text{s}$].
The plane is always perpendicular to the axis of heat flow.

9

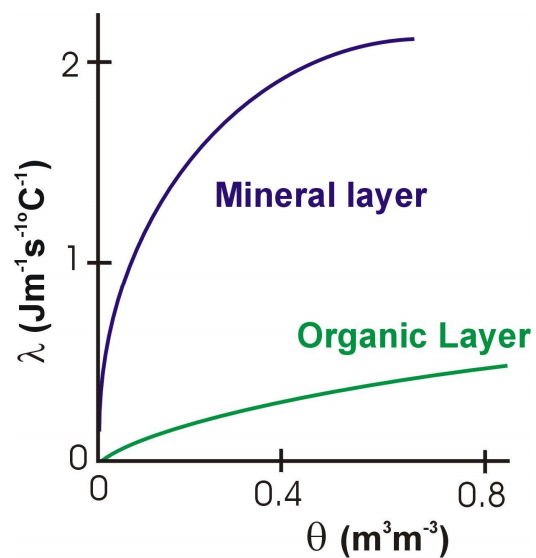


Thermal conductivity (λ)

describes heat flow in
response to a temperature
gradient [$\text{J/ms}^\circ\text{C}$]

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Thermal conductivity



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Heat conductor versus heat insulator

13

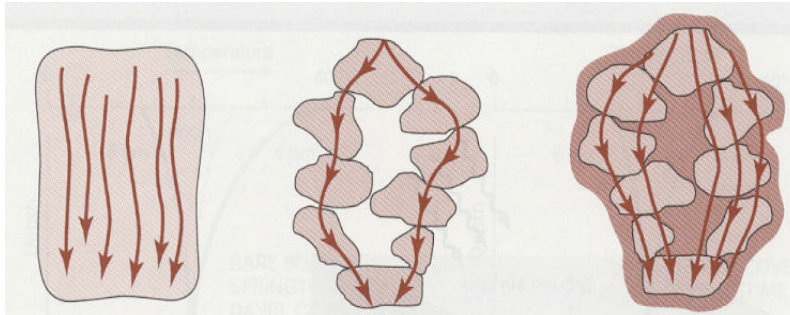
Thermal conductivity (λ) of soil components

Soil component	λ (J/msK°)
Quartz	8.368
Various soil minerals	2.930
Organic matter	0.251
Water	0.594
Air	0.026

From van Wijk & deVries, 1963

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Heat flow paths



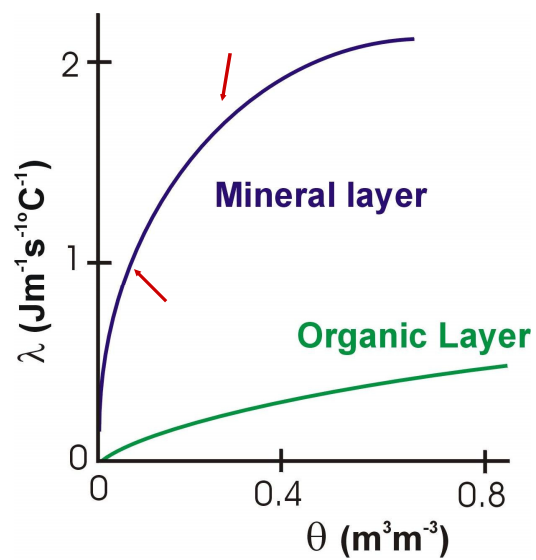
Solid rock (high λ)

Dry soil (low λ)

Wet soil (high λ)

15

Thermal conductivity



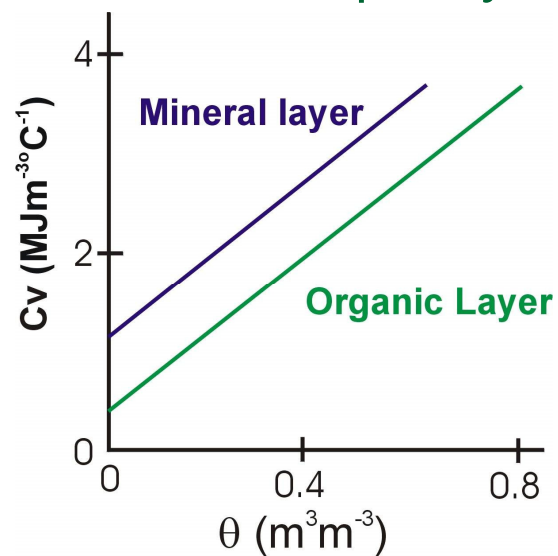
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Soil heat capacity (C_v)

represents the amount of heat needed to cause a 1°C change in temperature of a unit volume of soil [$\text{J}/\text{m}^3\text{C}$]

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Soil heat capacity



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Water has **HIGH** heat capacity

Air has **low** heat capacity

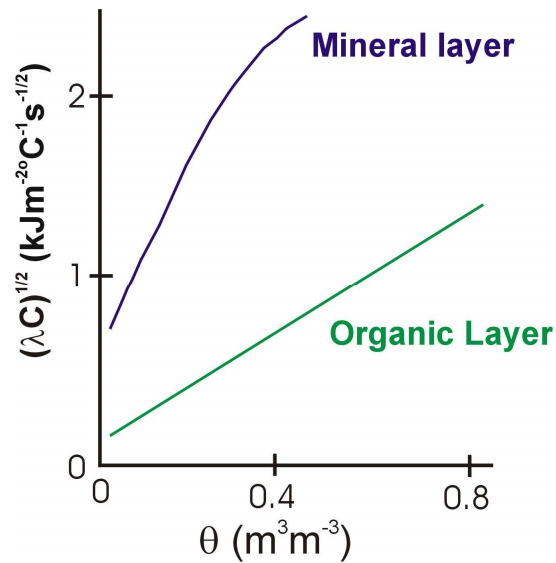
19

Thermal admittance $(\lambda C_v)^{1/2}$

represents ability of soil to accept and
release heat [kJ/m²°Cs]

20

Thermal admittance



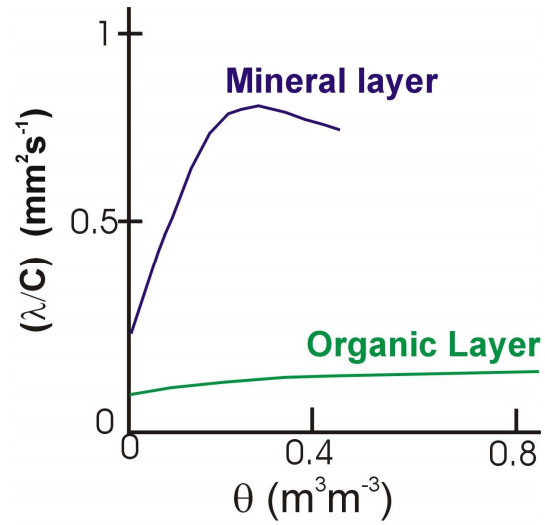
21

Thermal diffusivity (λ/C_v)

is an indication of **subsurface** temperature response to surface temperature change [m^2/s]

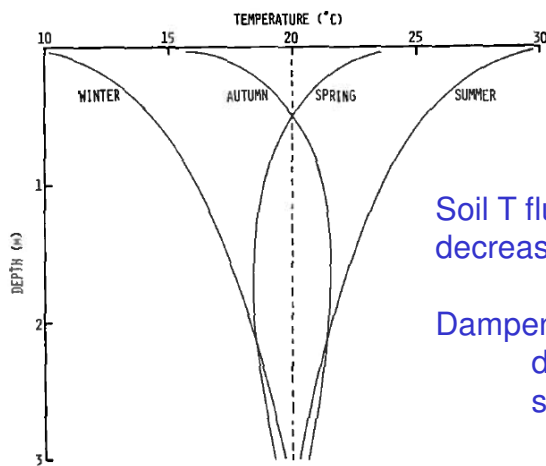
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Thermal diffusivity



23

Soil temperature profile



Soil T fluctuations (daily, annual)
decrease with depth

Dampening depth
deeper with higher λ
shallower with higher C_v

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Why are soils with low **thermal admittance** subject to extreme surface temperature fluctuations?



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Why does high thermal diffusivity result in large and rapid subsurface temperature responses to surface temperature change?



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Practices that can increase admittance and diffusivity

- Adding sand to organic soil
- Cultivation
- Adding water to dry soil
- Removal of organic surface layers